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with citric acid solution 30 and a lower chamber 31 containing a mass of sodium bicarbonate 32 (other effervescent couples could of course be used). A lower chamber 31 communicates with a pumping chamber 33 in cylindrical body 12 defined between the gas generator 17 and the piston 13.

Upper chamber 29 is bounded by a penetrable laminated foil membrane 34. A cutting member 35 is provided in the lower chamber 31 so as to rest against the membrane 34. The membrane 34 must create a barrier between the upper and lower chambers 29,31 yet be penetrable. The upper and lower chambers 29,31 are connected together by a circumferential seal 36.

The upper chamber 29 is provided with a flexible peripheral portion 37 adjacent to the seal 36. Because of its flexibility, the peripheral portion 37 imparts a small amount of freedom of movement of upper chamber 29 towards lower chamber 31. Therefore, if the gas generator 27 is mechanically compressed, the upper chamber 29 moves towards the lower chamber 31 resulting in the penetration of the foil membrane 34 by the cutting member 35.

Downward pressure on the barrel 11 results in the situation shown in FIG. 5. The sleeve 20 pushes the flange 27 and hence the cylindrical body 12 and the gas generator 17 upwards within the barrel 11. When the gas generator 17 reaches the top of barrel 11 it is compressed. This compression causes cutting member 35 to penetrate foil membrane (not visible in FIG. 5), releasing citric acid 30 into contact with sodium bicarbonate 32. This results in the immediate generation of carbon dioxide causing the pumping chamber 33 to become pressurised, which in turn drives the piston 13 downwards to deliver the liquid 14 from cylindrical body 12 to the injection site 25 via the needle 15.

When delivery has been completed (this may suitably take of the order of 3-5 seconds, although longer or shorter times can be achieved if required), gas generation will generally not have been completed: a surplus of reactive gas generating materials is provided so as to ensure completion of delivery. In order to prevent any dangerous pressure build up a release valve 38 is provided on the gas generator 17. The release valve 38 opens when pressure reaches a predetermined level. Thus, release valve 38 is also actuated by any blockage in delivery.

When delivery has been completed, the barrel 11 is removed from the injection site 25. As the pressure on the barrel 11 is relieved, the spring 22 pushes the sleeve 20 from the second position (FIG. 5) back to the first position (FIG. 6). Thus, the needle 15 is concealed even before the sleeve 20 has left the injection site 25. For severely needlephobic patients, any sight of the needle must be avoided if possible, and for safety reasons, it is highly preferable that the needle is never exposed. As a result of the slot 23 and the location of the peg 24 in the first position (as shown in FIG. 7D), the sleeve 20 is locked in the first position when it returns from the second position and the pressure of the spring 22 prevent it from returning to the second position, as will be discussed in more detail below.

FIGS. 7A-7D illustrate the operation of the safety locking mechanism by showing the position of the peg 24 (mounted in the interior of barrel 11) in the slot 23 formed in the sleeve 20, at four stages of the delivery procedure, with FIGS. 7A-7D corresponding to FIGS. 3-6, respectively.

As indicated previously, the sleeve 20 is biased to the first position (FIGS. 3 and 7A) by a coil spring 22, illustrated in FIG. 8. The ends of spring 22 form two outward projections 39, one of which engages barrel 11 and the other of which engages the sleeve 20. In addition to providing an axial

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biasing, spring 22 rotationally biases the sleeve 20 relative to the barrel 11 towards an equilibrium position, but the slot 23 and peg 24 constrain the relative rotation of the barrel 11 and the sleeve 20.

The equilibrium position is indicated in FIGS. 7A-7D by a dotted line, which is the equilibrium position of the peg 24 in barrel 11 relative to the sleeve 20. Accordingly, in FIGS. 7A-7C the peg 24 is to the left of the relaxed equilibrium position (in the view shown), resulting in a rotational bias of the sleeve 20 relative to the barrel 11 which would cause the peg to move to the right. In FIG. 7D, the peg is effectively at the equilibrium position.

As the peg 24 is constrained in the slot, it has to follow the path illustrated in FIGS. 7A-7C as the sleeve moves from the first position (FIG. 7A) to the second position (FIG. 7C). When delivery is completed and the pressure on the barrel is released, the sleeve is axially moved from the second position (FIG. 7C) to the first position. The rotational biasing of the spring 22, however, causes the peg 24 to travel into the right-hand arm 40 of the slot 23 (FIG. 7C), rather than the left-hand arm 41 in which it started. When the sleeve 20 has moved most of the way back towards the first position (just before the point illustrated in FIG. 7D), the peg 24 is biased to move leftwards (as seen in the view of FIGS. 7A-7D) and passes the top right-hand corner 42 of the slot 23. At this point the peg is free to move leftwards, and thus it springs to the position shown in FIG. 7D, i.e. the barrel 11 and the sleeve 20 rotate relative to one another under the influence of the spring 22 to reach the FIG. 7D position.

When the peg 24 is in the position shown in FIG. 7D it is effectively trapped, and any attempt to move the sleeve 20 axially relative to the barrel 11 results in the peg 24 being stopped in the small notch 43. Accordingly, after a single reciprocation from the first position to the second position and back to the first position, the sleeve 20 is locked and the needle 22 is permanently concealed.

FIG. 9 shows the syringe 10 in perspective view before use. Thus, barrel 11, sleeve 20, and needle cover 16 can be seen. Also visible are slot 23 and the position of pin 24. A further feature is a transparent window 44 which allows the user to see when the delivery of liquid is complete so that the syringe 10 can be removed.

The needle 15 is preferred to extend from the sleeve by 1-3 mm, most preferably by 1 mm in length. In addition the ratio of citric acid to sodium bicarbonate in the gas generator should be sufficient to preferably generate a delivery pressure of approximately 2 atmospheres. This enables the syringe 10 to deliver the liquid 14 to the user automatically at a low pressure and with a reduced risk of injury.

FIG. 10 shows a first alternative embodiment of the present invention. It is similar to the syringe described in detail above except that it has a needle cover different from that shown in FIG. 1. FIG. 10 shows a needle cover 40 shaped to fit over the needle 15. The needle cover also has a radial groove 41 located at the opposed end of the needle on the exterior of the cover. The needle cover 40 and sleeve 20 are covered by a cap 42. The cap 42 has an interior groove 43 that matingly receives the radial groove of the needle cover 40 when the cap is placed over the needle cover 40 and sleeve 20. The cap 42 maintains the sterility of the needle 15 until removal of the cap. When the cap 42 is pulled off the syringe prior to use, the mating pair of grooves cause the needle cover 40 to be pulled off at the same time. When the cap 42 is placed back over the sleeve 20, the needle cover 40 is also placed over the needle 15 to further avoid contamination and/or leakage of any remaining residue left within the syringe 10.

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FIG. 11 shows a second alternative embodiment of the present invention. FIG. 11 is similar to the embodiment shown in FIG. 10 but has a different cap 44 and needle cover 45. The cap 44 has an outer lip 46 that rests over the open end 19 of the barrel 11. The needle cover 45 is cylindrical in shape and covers the needle 15 and maintains its sterility until use. Prior to use, the user must first remove the cap 44, and then remove the needle cover 45. After use, the user must replace the needle cover 45 and then the cap 44 separately.

It will be appreciated that the embodiments discussed above are preferred embodiments, falling within the scope of the appended claims, and that various alternative embodiments are contemplated.

For example, other chemically reactive materials other than citric acid and sodium bicarbonate may be used in connection with the gas generator of the present invention. Other mechanisms other than the coil spring 22 may be used to exert upward pressure on the barrel 11 and activate the gas generator 17. Such alternative mechanisms include the use of any elastic or resilient member.

It is further appreciated that the present invention may be used to deliver a number of drugs. The term "drug" used herein includes but is not limited to peptides or proteins, hormones, analgesics, anti-migraine agents, anti-coagulant agents, narcotic antagonists, chelating agents, anti-anginal agents, chemotherapy agents, sedatives, anti-neoplastic agents, prostaglandins and antidiuretic agents.

Typical drugs include peptides, proteins or hormones such as insulin, calcitonin, calcitonin gene regulating protein, atrial natriuretic protein, colony stimulating factor, betaseron, erythropoietin (EPO), interferons such as α , β or γ interferon, somatropin, somatotropin, somatostatin, insulin-like growth factor (somatomedins), luteinizing hormone releasing hormone (LHRH), tissue plasminogen activator (TPA), growth hormone releasing hormone (GHRH), oxytocin, estradiol, growth hormones, leuprolide acetate, factor viii, interleukins such as interleukin-2, and analogues thereof; analgesics such as fentanyl, sufentanil, butorphanol, buprenorphine, levorphanol, morphine, hydromorphone, hydrocodone, oxycodone, methadone, lidocaine, bupivacaine, diclofenac, naproxen, paverin, and analogues thereof; anti-migraine agents such as sumatriptan, ergot alkaloids, and analogues thereof; anti-coagulant agents such as heparin, hirudin, and analogues thereof; anti-emetic agents such as scopolamine, ondansetron, domperidone, metoclopramide, and analogues thereof; cardiovascular agents, anti-hypertensive agents and vasodilators such as diltiazem, clonidine, nifedipine, verapamil, isosorbide-5-mononitrate, organic nitrates, agents used in treatment of heart disorders, and analogues thereof; sedatives such as benzodiazepines, phenothiazines, and analogues thereof; chelating agents such as deferoxamine, and analogues thereof; anti-diuretic agents such as desmopressin, vasopressin, and analogues thereof; anti-anginal agents such as nitroglycerine, and analogues thereof; anti-neoplastics such as fluorouracil, bleomycin, and analogues thereof; prostaglandins and analogues thereof; and chemotherapy agents such as vincristine, and analogues thereof.

What is claimed is:

1. A syringe comprising:

- a barrel having a liquid drug reservoir therein, the barrel having a first end and a second end;
- a delivery needle mounted on the first end of the barrel;
- a gas generator located at the second end of the barrel, the gas generator in communication with the reservoir when the gas generator is activated;

d) gas generation activation means; and

e) a sleeve moveably mounted on the first end of the barrel from a first position where the tip of the needle is concealed by the sleeve to a second position where the tip of the needle is exposed to a third gas generation activation position,

f) whereby when the sleeve is initially pressed against an injection site, the sleeve moves from the first position to the second position, and the tip of the needle penetrates the injection site, and when the sleeve moves from the second position to the third position, it causes activation of the gas generator which drives a liquid from the reservoir into the injection site through the needle.

2. The syringe of claim 1 wherein the gas generator comprises first and second chambers separated by a deformable membrane.

3. The syringe of claim 2 wherein the gas activation means comprises means for puncturing the deformable membrane.

4. The syringe of claim 2 wherein the first and second chambers house the components of an effervescent couple respectively.

5. The syringe of claim 4 wherein at least one of the components of the couple is a liquid.

6. The syringe of claim 4 wherein the components of the effervescent couple are citric acid and sodium bicarbonate respectively.

7. The syringe of claim 1 wherein the gas activation means is activated by movement of the barrel and sleeve from the first position to the second position.

8. The syringe of claim 1 wherein the sleeve is axially biased towards the first position so that it moves to the first position when no pressure is applied to the barrel.

9. The syringe of claim 8 wherein the sleeve is axially biased by means of a coil spring.

10. The syringe of claim 9 wherein the coil spring is disposed between the sleeve and the barrel.

11. The syringe of claim 5 wherein the sleeve is torsionally biased.

12. The syringe of claim 11 wherein the axial and torsional bias are provided by a compression-extension spring under torsional strain.

13. The syringe of claim 1 further comprising locking means such that when the sleeve returns from the second position to the first position the locking means prevents the sleeve from returning to the second position.

14. The syringe of claim 13 wherein the locking means comprises a pair of co-operating formations disposed on the sleeve and the barrel respectively.

15. The syringe of claim 14 wherein the pair of co-operating formations comprises a slot and a member received in the slot respectively.

16. The syringe of claim 1 wherein the needle extends between about 1-3 mm beyond the first end of the barrel.

17. The syringe of claim 1 wherein the needle extends approximately 1 mm beyond the first end of the barrel.

18. The syringe of claim 1 wherein the gas generator generates a pressure of about 2 atmospheres.

19. A method of injecting liquid drug comprising the following steps:

- providing a barrel having a liquid drug reservoir therein, a delivery needle mounted on the first end of the barrel,
- locating a gas generator at the second end of the barrel, the gas generator in communication with the reservoir when the gas generator is activated;